Hazard Profile – Severe Storm

Introduction[1, 2]

All areas of Washington State are vulnerable to severe weather. A severe storm is an atmospheric disturbance that results in one or more of the following phenomena: strong winds and large hail, thunderstorms, tornados, rain, snow, or other mixed precipitation. Typically, major impacts from a severe storm are to transportation and loss of utilities. Most storms move into Washington from the Pacific Ocean.

The following severe storm elements are considered for this profile (using National Weather Service definitions):

- High winds – Storms with sustained winds of 40 mph or gusts of 58 mph or greater, not caused by thunderstorms, expected to last for an hour or more.

- Severe Thunderstorm – Storms that produce winds of 58 mph or greater or three-quarter inch or larger hail.

- Tornado – A storm with a violently rotating column of air that contacts the ground; tornados usually develop from severe thunderstorms. Tornados can produce winds of 100 to 300 mph.

- Winter storm – A storm with significant snowfall, ice, and/or freezing rain; the quantity of precipitation varies by elevation. Heavy snowfall is 4 inches or more in a 12-hour period, or 6 or more inches in a 24-hour period in non-mountainous areas; and 12 inches or more in a 12-hour period or 18 inches or more in a 24-hour period in mountainous areas.

- Blizzard – A storm with considerable falling and/or blowing snow combined with sustained winds or frequent gusts of 35 mph or greater that frequently reduces visibility to less than one-quarter mile. Blizzards typically are confined to the Columbia River Gorge and Northwest Washington near the Fraser River Valley of British Columbia.

- Dust storm – A storm of dust and debris blown by wind gusts of at least 35 mph, or caused by a downburst from a dry thunderstorm, that reduces visibility to less than one-quarter mile.

- Coastal flooding – Flooding in coastal areas caused by storm surge, astronomical high tides, or a combination of them.

Note: Although flooding is a result of severe rainstorms, see Tab 7.1.4 for a separate profile on the flood hazard.

Washington's Climate[3]

The location of the State of Washington on the windward coast in mid-latitudes is such

that climatic elements combine to produce a predominantly marine-type climate west of the Cascade Mountains, while east of the Cascades, the climate possesses both continental and marine characteristics.

The state's climate is impacted by two significant factors:

- Mountain ranges. The Olympic Mountains and the Cascade Mountains affect rainfall. The first major release of rain occurs along the west slopes of the Olympics, and the second is along the west slopes of the Cascade Range. Additionally, the Cascades are a topographic and climatic barrier. Air warms and dries as it descends along the eastern slopes of the Cascades, resulting in near desert conditions in the lowest section of the Columbia Basin in eastern Washington. Another lifting of the air occurs as it flows eastward from the lowest elevations of the Columbia Basin toward the Rocky Mountains. This results in a gradual increase in precipitation in the higher elevations along the northern and eastern borders of the state.

- Location and intensity of semi-permanent high and low-pressure areas over the North Pacific Ocean. During the summer and fall, circulation of air around a high-pressure area over the North Pacific brings a prevailing westerly and northwesterly flow of comparatively dry, cool and stable air into the Pacific Northwest. As the air moves inland, it becomes warmer and drier, resulting in a dry season. In the winter and spring, the high pressure resides further south while low pressure prevails in the Northeast Pacific. Circulation of air around both pressure centers brings a prevailing southwesterly and westerly flow of mild, moist air into the Pacific Northwest. Condensation occurs as the air moves inland over the cooler land and rises along the windward slopes of the mountains. This results in a wet season beginning in late October or November, reaching a peak in winter, gradually decreasing by late spring.

West of the Cascade Mountains, summers are cool and relatively dry while winters are mild, wet and generally cloudy.

In interior valleys, measurable rainfall occurs on 150 days each year and on 190 days in the mountains and along the coast. Thunderstorms over the lower elevations occur up to 10 days each year and over the mountains up to 15 days. Damaging hailstorms rarely occur in most localities of western Washington. During July and August, the driest months, two to four weeks can pass with only a few showers; however, in December and January, the wettest months, precipitation is frequently recorded on 20 to 25 days or more each month. The range in annual precipitation is from about 20 inches in an area northeast of the Olympic Mountains to 150 inches along the southwestern slopes of these mountains. Snowfall is light in the lower elevations and heavy in the mountains.

During the wet season, rainfall is usually of light to moderate intensity and continuous over a period of time, rather than heavy downpours for brief periods; heavier intensities

occur along the windward slopes of the mountains.

The strongest winds are generally from the south or southwest and occur during the fall and winter. In interior valleys, wind velocities reach 40 to 50 mph each winter, and 75 to 90 mph a few times every 50 years. The highest summer and lowest winter temperatures generally occur during periods of easterly winds.

The climate east of the Cascade Mountains has characteristics of both continental and marine climates. Summers are warmer, winters are colder, and precipitation is less than in western Washington. Extremes in both summer and winter temperatures generally occur when air from the continent influences the inland basin.

In the driest areas, rainfall occurs about 70 days each year in the lowland and about 120 days in the higher elevations near the eastern border and along the eastern slopes of the Cascades. Annual precipitation ranges from seven to nine inches near the confluence of the Snake and Columbia Rivers in the Tri-Cities area, 15 to 30 inches along the eastern border and 75 to 90 inches near the summit of the Cascade Mountains. During July and August, four to eight weeks can pass with only a few scattered showers. Thunderstorms, most as isolated cells, occur on one to three days each month from April through September. A few damaging hailstorms are reported each summer.

During the coldest months, freezing drizzle occasionally occurs, as does a Chinook wind that produces a rapid rise in temperature.

During most of the year, the prevailing wind is from the southwest or west. The frequency of northeasterly winds is greatest in the fall and winter. Wind velocities ranging from four to 12 mph can be expected 60 to 70 percent of the time; 13 to 24 mph, 15 to 24 percent of the time; and 25 mph or higher, 1 to 2 percent of the time. The highest wind velocities are from the southwest or west and are frequently associated with rapidly moving weather systems. Extreme wind velocities can be expected to reach 50 mph at least once in two years; 60 to 70 mph once in 50 years; and 80 mph once in 100 years.

Hazardous Weather Seasons[4]

Primary flood season

- Western Washington – November through February.
- Eastern Washington (east slopes of Cascades) – May and June.

Windstorm season – October through March.

Snow season:

- Western Washington – mid November through mid March.
- Eastern Washington – November through March.
- Mountains – mid October through May.

Significant Severe Storms in Washington State – 1900 to Present

Note: Severe storms that resulted in flooding are described in more detail in the Flood hazard profile.

January/February 1916 – Seattle's Greatest Snowstorm[5]

One of the top 10 weather events in Washington during the 20th Century, according to the National Weather Service, Seattle Forecast Office.

Seattle's snowfall in January was 23 inches, and February snowfall was 35 inches, for a two-month total of 58 inches.

Seattle recorded its maximum snowfall ever in a 24-hour period, with 21.5 inches on February 1. Other parts of western Washington received between two to four feet of snow. Winds created snowdrifts as high as five feet.

The region was crippled, with transportation essentially halted.

May/June 1948 – Greatest Spring Snowmelt Flooding[6]

One of the top 10 weather events in Washington during the 20th Century, according to the National Weather Service, Seattle Forecast Office.

Snowmelt flooding broke lake and river records in Eastern Washington and along the Columbia River to the Pacific Ocean. Flood lasted 45 days.

Vancouver, Camas, Kalama, and Longview suffered flood damage.

January 13, 1950 – The January 1950 Blizzard[7]

One of the top 10 weather events in Washington during the 20th Century, according to the National Weather Service, Seattle Forecast Office.

On this date, 21.4 inches of snow fell in Seattle, the second greatest 24-hour snowfall recorded. The snowfall was accompanied by 25-40 mph winds. The storm claimed 13 lives in the Puget Sound area.

January had 18 days with high temperatures of 32 degrees or lower. The winter of 1949-50 was the coldest winter on record in Seattle, with an average temperature of 34.4 degrees.

Eastern Washington, North Idaho, and parts of Oregon also were paralyzed by the snow – some lower-elevation snow depths reached nearly 50 inches and temperatures plunged into minus teens and twenties. Several dozen fatalities occurred.

October 12, 1962 – The Columbus Day Wind Storm[8, 9]

The top weather event in Washington during the 20th Century, according to the National Weather Service, Seattle Forecast Office.

This storm is the greatest windstorm to hit the Northwest since weather recordkeeping began in the 19th century, and called the "mother of all wind storms" in the 1900s. All windstorms in the Northwest are compared to this one.

The Columbus Day Storm was the strongest widespread non-tropical windstorm to strike the continental U.S. during the 20th century, affecting an area from northern California to British Columbia.

The storm claimed seven lives in Washington State; 46 died throughout the impacted region. One million homes lost power. More than 50,000 homes were damaged. Total property damage in the region was estimated at $235 million (1962 dollars). The storm blew down 15 billion board feet of timber worth $750 million (1962 dollars); this is more than three times the timber blown down by the May 1980 eruption of Mount St. Helens, and enough wood to replace every home in the state.

Highest recorded wind speeds (before power went out at recording stations):

- Naselle, Washington Coast – gust to 160 mph.
- Bellingham and Vancouver – gusts of 113 mph.
- Renton – gust of 100 mph.
- Tacoma – gust of 88 mph.

April 5, 1972 – Washington's Deadliest Tornado Outbreak[10, 11]

One of the top 10 weather events in Washington during the 20th Century, according to the National Weather Service, Seattle Forecast Office.

Three tornadoes touched down in Washington State on this day:

- An F3 tornado touched down in Vancouver; it swept through a grocery store, bowling alley, and grade school near where Vancouver Mall is today. It caused six deaths, 300 injuries, and $50 million in damage.
- Later that day, another F3 tornado touched down west of Spokane near Davenport, and an F2 tornado struck rural Stevens County.
- Numerous severe thunderstorms with large hail and damaging winds were reported over other areas of eastern Washington.

An F3 tornado has winds of 158-206 mph, and is capable of severe damage. An F2 tornado has winds of 113-157 mph and is capable of considerable damage.

Because of these tornados, Washington led the nation in tornado deaths in 1972.

December 1982[12]

Federal Disaster #676. Disaster assistance provided – $1.7 million. Small Business Administration loaned $1 million to home and business owners for damages.

Severe storm and coastal flooding affected Whatcom County. Four persons injured, 122 people evacuated; 129 homes and 113 businesses damaged; $1.7 million in public facility damage.

November 1990 – Statewide Flooding[13, 14]

Federal Disaster #883. Stafford Act disaster assistance provided – $57 million.

One of the top 10 weather events in Washington during the 20th Century, according to the National Weather Service, Seattle Forecast Office.

Widespread, major flooding on western Washington rivers and several eastern Washington rivers.

This storm caused two deaths. Damage estimated at $250 million. The Interstate 90 – Lake Washington floating bridge between Seattle and Mercer Island sank during this storm event.

December 1990 – Severe Storm

Federal Disaster #896. Stafford Act disaster assistance provided – $5.1 million.

Floods, snow, and high winds affected the counties of Island, Jefferson, King, Kitsap, Lewis, Pierce, San Juan, Skagit, Snohomish, and Whatcom.

January 20, 1993 – The Inauguration Day Wind Storm[15, 16]

Federal Disaster #981. Stafford Act disaster assistance provided – $24.2 million.

Hurricane force winds swept King, Lewis, Mason, Pierce, Snohomish, Thurston and Wahkiakum counties.

This storm claimed five lives. More than 870,000 homes and businesses lost power. Fifty-two single-family homes, mobile homes, and apartment units were destroyed, and 249 incurred major damage, many from falling trees and limbs. More than 580 businesses were damaged. Total damage in western Washington estimated at $130 million.

Winds in Puget Sound area gusted to 70 mph. A gust at Cape Disappointment on the Washington Coast reached 98 mph.

February 1996 – Storm with Widespread Flooding, Snowmelt, Mudslides in Washington, Oregon, and Idaho[17, 18]

Federal Disaster #1100. Stafford Act disaster assistance provided – $113 million. Small Business Administration disaster loans approved - $61.2 million.

One of the top 10 weather events in Washington during the 20th Century, according to the National Weather Service, Seattle Forecast Office.

Heavy rainfall, mild temperatures and snowmelt caused flooding and mudslides in Adams, Asotin, Benton, Clark, Columbia, Cowlitz, Garfield, Grays Harbor, King, Kitsap, Kittitas, Klickitat, Lewis, Lincoln, Pierce, Skagit, Skamania, Snohomish, Spokane, Thurston, Wahkiakum, Walla Walla, Whitman and Yakima counties, and the Yakama Indian Reservation.

This storm caused major flooding on rivers of western and southeast Washington. (See Flood hazard profile, Tab 7.1.4, pages 8-9, for more.)

Mudslides occurred throughout the state.

Three deaths, 10 people injured. Nearly 8,000 homes damaged or destroyed. Traffic flow both east and west, and north and south along major highways was shut down for several days. An avalanche closed Interstate 90 at Snoqualmie Pass. Mudslides in Cowlitz County and flooding in Lewis County closed Interstate 5. Damage throughout the Pacific Northwest estimated at $800 million.

November 1996 – Spokane Area Ice Storm[19, 20]

Federal Disaster #1152. Stafford Act disaster assistance provided – $11.9 million.

Heavy rain, freezing rain and snow fell in Spokane, Pend Oreille, and Klickitat counties.

Up to three inches of ice was deposited on trees, vehicles, buildings, etc., across much of the populated areas of Spokane County. More than 100,000 homes and businesses lost power; some were without power for up to nine weeks. Power outage affected water and sewage pumping systems. Spokane International Airport was closed for two days due to power outage.

Four people died; damage estimated at more than $22 million dollars.

December 1996 - January 1997 – Ice, Wind, Flooding, Snowloading, Landslides[21]

Federal Disaster #1159. Stafford Act disaster assistance provided – $83 million. Small Business Administration loans approved – $31.7 million.

Saturated ground combined with snow, freezing rain, rain, rapid warming and high winds within a five-day period produced flooding and landslides.

Impacted counties – Adams, Asotin, Benton, Chelan, Clallam, Clark, Columbia, Cowlitz, Douglas, Ferry, Franklin, Garfield, Grant, Grays Harbor, Island, Jefferson, King, Kitsap, Kittitas, Klickitat, Lewis, Lincoln, Mason, Okanogan, Pacific, Pend Oreille, Pierce, San Juan, Skagit, Skamania, Snohomish, Spokane, Stevens, Thurston, Walla Walla, Whatcom, and Yakima.

Twenty-four deaths; $140 million (est.) in insured losses; 250,000 people lost power.

More than 130 landslides between Seattle and Everett, primarily along shorelines. Interstate 90 at Snoqualmie Pass was closed due to avalanche.

May 31, 1997 – Tornado Outbreak[22, 23]

A record six tornados touched down in Washington in one day; the state's previous record was four tornados in 1989 for the entire year.

- Four F1 tornados hit Stevens and Spokane counties in northeast Washington.
- Two F0 tornados touched down in western Washington – Vancouver and Tacoma.
- Also, on the same day in Idaho, an F1 tornado struck Athol and an F0 was observed near Lewiston.

In addition, this storm produced severe thunderstorms with large hail up to two to three inches in diameter, heavy rain and flash flooding, and wind gusts to near 80 mph. An F0 tornado has winds of 40-72 miles per hour and is capable of light damage. An F1 tornado has winds of 73-112 mph and is capable of moderate damage.

No deaths or injuries reported.

A record 14 tornados were reported in the state in 1997.

Summary of Impacts of Hazardous Weather in Washington State – 1995 to 2001[24]

Year	Fatalities	Injuries	Property Damage	Crop Damage
1995	3	2	$10.3 million	not listed
1996	13	34	$63.9 million	$5.7 million
1997	26	21	$23.6 million	$900,000
1998	4	15	$22.9 million	$85.4 million
1999	6	15	$39.7 million	$300,000
2000	3	21	$11.2 million	$100,000
2001	11	19	$7.6 million	$95.5 million
Totals	**66**	**127**	**$179.2 million**	**$187.9 million**

Jurisdictions Most Vulnerable to Severe Storms

For the State Hazard Mitigation Plan, factors used to determine which counties are most vulnerable to future non-flood, severe storm are:

- Counties most vulnerable to the non-flood meteorological criteria below, as determined by Ted Buehner, Warning Coordination Meteorologist, National Weather Service – Seattle; Tyree Wilde, Warning Coordination Meteorologist, National Weather Service – Portland, OR; Ken Holmes, Warning Coordination Meteorologist, National Weather Service – Spokane; and Dennis Hull, Warning Coordination Meteorologist, National Weather Service – Pendleton, OR.

- How often severe storm events occur, expressed as a percentage of recurrence per year. The percentage used to differentiate jurisdictions most vulnerable differs by storm type and is explained below.

  Data for frequency of severe storm events was obtained from the Special Hazard Events and Losses Database for the United States (SHELDUS, beta version), developed by the Hazard Research Lab at the University of South Carolina, and from the National Climatic Data Center of the National Oceanic and Atmospheric Administration.

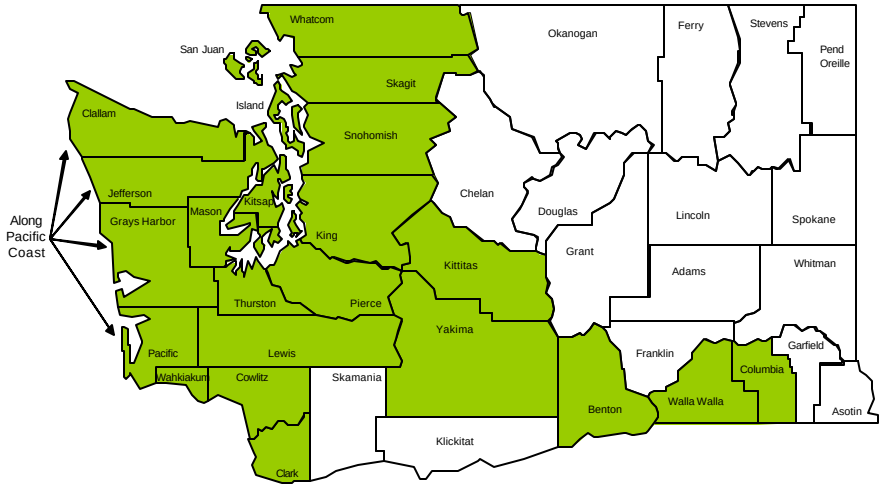
  SHELDUS uses a variety of NOAA data sources. It covers severe weather events from 1960 through 2000 that caused more than $50,000 in property and/or crop damage. Data obtained from the National Climatic Data Center covered weather events causing more than $100,000 in property and/or crop damage from 1993 through 2003 (except June and July 1993, for which data is not available), with the following exceptions:
  - Tornado information is from 1950 to 1992.
  - Thunderstorm wind and hail information is from 1955 to 1992.

  Analysis of the data sets eliminated duplicate entries between the SHELDUS and National Climatic Date Center data.

The severe storm events for each county's vulnerability are the following:

High winds – The National Weather Service defines high winds as sustained winds of 40 mph or gusts of 58 mph or greater, not caused by thunderstorms, expected to last for an hour or more.

Counties Most Vulnerable to High Winds

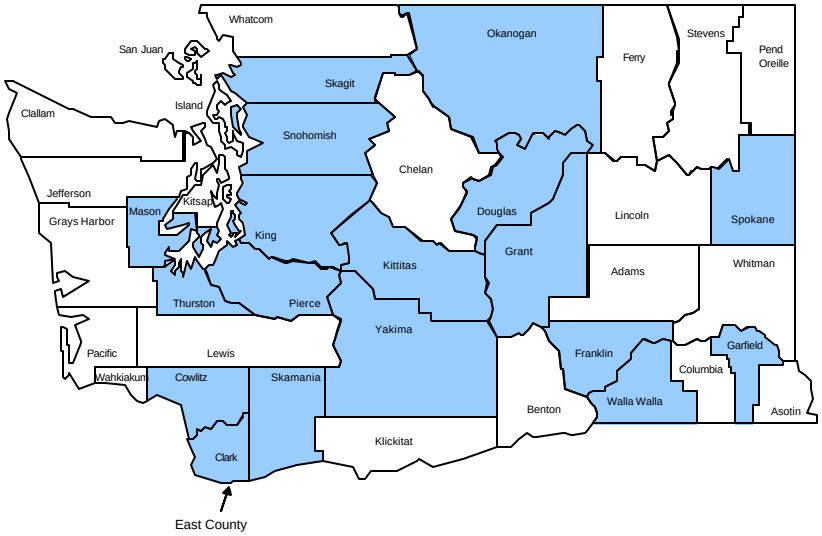


Areas most vulnerable to high winds are those affected by a strong pressure difference from deep storms originating over the Pacific Ocean; an outbreak of very cold, Arctic air originating over Canada; or air pressure differences between western and eastern Washington that primarily affect the Columbia River Gorge, Cascade Mountain passes, ridges and east slopes, and portions of the Columbia Basin.

Counties considered most vulnerable to high winds are 1) those most affected by conditions that lead to high winds, as described above, **and** 2) those with a high wind recurrence rate of 100 percent, meaning the county experiences at least one damaging high wind event every year. Counties that meet both criteria are highlighted in Table 1, page 17, and on the map, above.

Winter storm – The National Weather Service defines a winter storm as having significant snowfall, ice, and/or freezing rain; the quantity of precipitation varies by elevation. Heavy snowfall is 4 inches or more in a 12-hour period, or 6 inches or more in a 24-hour period in non-mountainous areas; and 12 inches or more in a 12-hour period or 18 inches or more in a 24-hour period in mountainous areas.

Counties Most Vulnerable to Winter Storm

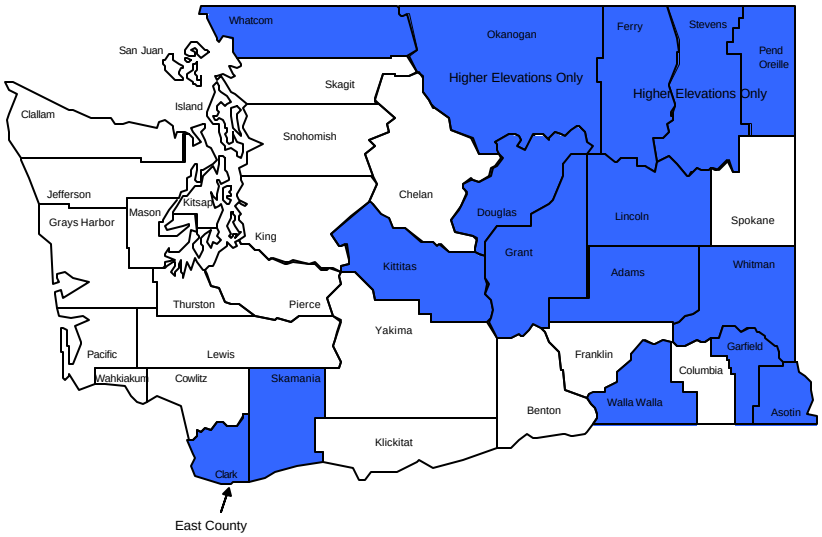


Areas most vulnerable to winter storms are those affected by convergence of dry, cold air from the interior of the North American continent, and warm, moist air off the Pacific Ocean. Typically, significant winter storms occur during the transition between cold and warm periods.

Counties considered most vulnerable to winter storm are 1) those most affected by conditions that lead to such storms, as described above, **and** 2) those with a recurrence rate of 50 percent, meaning the county experiences at least one damaging winter storm event every two years. Counties that meet both criteria are highlighted in Table 2, page 18, and on the map above.

Blizzard – The National Weather Service defines a blizzard as having considerable falling and/or blowing snow combined with sustained wind or frequent gusts of 35 mph or greater often resulting in visibility reduced to less than one-quarter mile.

Counties Most Vulnerable to Blizzard

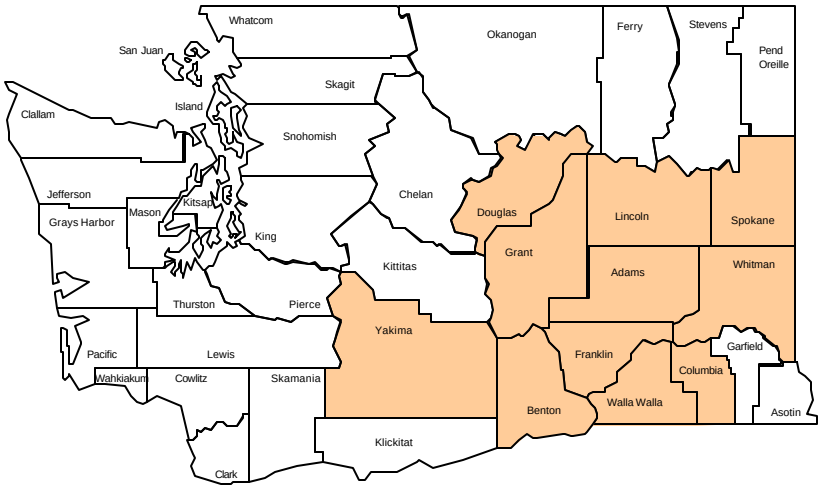


Areas most vulnerable to blizzards are those subject to the combination of winter storms and high winds.

Counties considered most vulnerable to blizzard are 1) those most affected by conditions that lead to blizzard, as described above, **or** 2) those with a blizzard recurrence rate of 2.5 percent, meaning the county experiences at least one damaging high wind event every 40 years. Counties highlighted in Table 3, page 19, and on the map, page above, meet one of the above criteria; counties only need to meet one of the two criteria to be considered most vulnerable because a lack of data exists on blizzard events.

Dust storm – The National Weather Service defines a dust storm as a storm of dust and debris blown by wind gusts of at least 35 mph, or caused by a downburst from a dry thunderstorm, that reduces visibility to less than one-quarter mile.

Counties Most Vulnerable to Dust Storm



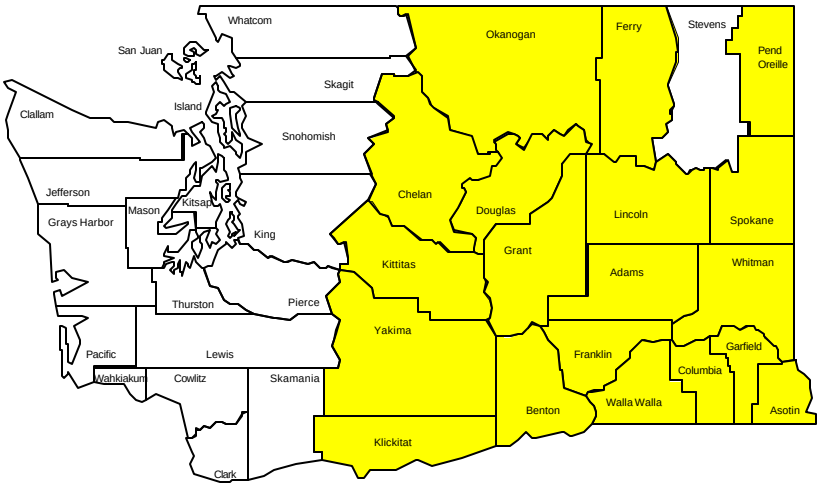
Areas most vulnerable to dust storms are those with significant acreage of open fields, that have extensive dry periods, and that experience a strong front moving over the area.

Counties considered most vulnerable to dust storm are 1) those most affected by conditions that lead to such storms, as described above, **and** 2) those with a dust storm recurrence rate of 2.5 percent, meaning the county experiences at least one damaging dust storm event every 40 years. Counties highlighted in Table 4, page 20, and on the map, above, meet both criteria

Severe Thunderstorm – The National Weather Service defines a severe thunderstorm as a storm that produces winds of at least 58 mph, or three-quarter inch or larger hail.

Areas most vulnerable to this type of storm are those subject to a strong southwesterly flow of moist, unstable air that generates strong, sometimes violent thunderstorms with one or more of the following characteristics: strong damaging winds, large hail, waterspouts, or tornados.

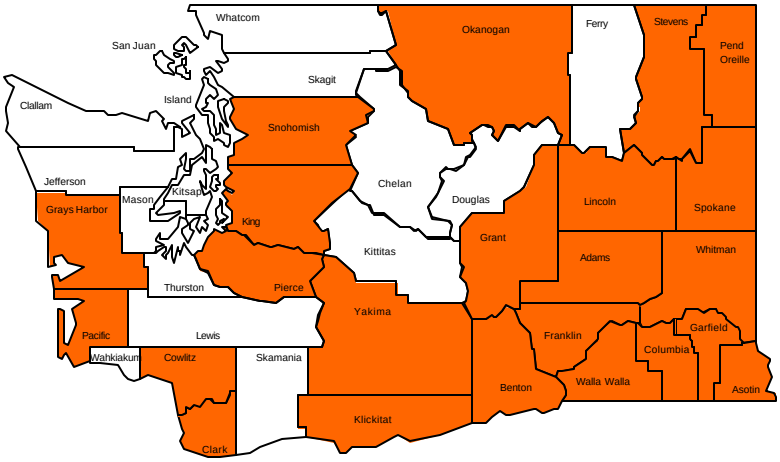
Counties Most Vulnerable to Severe Thunderstorm



Counties considered most vulnerable to severe thunderstorm are 1) those most affected by conditions that lead to such storms, as described above, **or** 2) those with a recurrence rate of 20 percent or greater, meaning the county experiences one damaging severe thunderstorm event at least once every five years. Counties highlighted in Table 5, page 21, and on the map, above, meet both criteria.

Tornado – The National Weather Services defines a tornado as a violently rotating column of air that contacts the ground; tornados usually develop from severe thunderstorms.

Counties Most Vulnerable to Tornado



Areas most vulnerable to tornado are those subject to severe thunderstorms, as described above.

Counties considered most vulnerable to tornado are 1) those most affected by conditions that lead to such storms, as described above, **or** 2) those with a recurrence rate of 5 percent or greater, meaning the county experiences one damaging severe thunderstorm event at least once every 20 years.

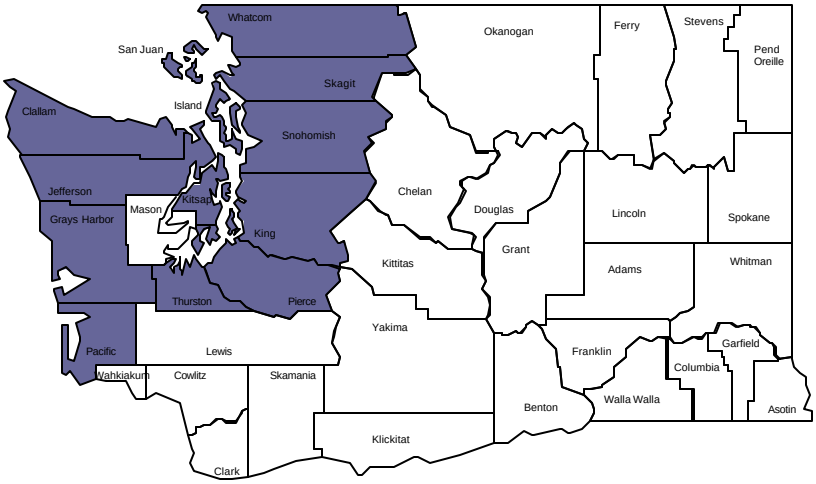
Counties highlighted in Table 6, page 22, and on the map above, meet one of the above criteria; counties only need to meet one of the criteria to be considered as most vulnerable because the occurrence of tornados is uncommon in Washington.

Coastal flooding – The National Weather Service defines coastal flooding as flooding of shoreline areas on the Pacific Coast and inland waters caused by storm surge, astronomical high tides, or a combination of the two.

Areas most vulnerable to coastal flooding are those with shorelines subject to the influence of storm surge and astronomical high tides.

Counties Most Vulnerable to Coastal Flooding

(Shoreline Areas Only)



Counties considered most vulnerable to coastal flooding are 1) those most affected by conditions that lead to such flooding, as described above, **and** 2) those with coastal flooding recurrence rate of 2.5 percent, meaning the county experiences at least one damaging storm causing coastal flooding every 40 years. Counties highlighted in Table 7, page 23, and on the map above, meet both criteria.

Table 1. Counties Most Vulnerable to High Winds (shade indicates most vulnerable)

	Vulnerable to Meteorological Conditions	Recurrence Rate (>100% – At least 1 occurrence per year)
Adams	YES	70%
Asotin	NO	70%
Benton	YES	140%
Chelan	YES, East Slopes of Cascades	63%
Clallam	YES, Pacific Coast	118%
Clark	YES	130%
Columbia	YES	120%
Cowlitz	YES	113%
Douglas	NO	80%
Ferry	YES, Higher Elevations	65%
Franklin	NO	80%
Garfield	YES	70%
Grant	YES	93%
Grays Harbor	YES	170%
Island	YES	148%
Jefferson	YES, Pacific Coast	125%
King	YES	133%
Kitsap	YES	125%
Kittitas	YES	110%
Klickitat	YES	73%
Lewis	YES	123%
Lincoln	YES	75%
Mason	YES	165%
Okanogan	YES	83%
Pacific	YES, Pacific Coast	213%
Pend Oreille	YES	73%
Pierce	YES	165%
San Juan	YES, Western Half	173%
Skagit	YES	188%
Skamania	YES	95%
Snohomish	YES, Western Half	175%
Spokane	NO	105%
Stevens	YES, Higher Elevations	83%
Thurston	YES	175%
Wahkiakum	YES	118%
Walla Walla	YES	90%
Whatcom	YES, Western Half	190%
Whitman	YES	93%
Yakima	YES	103%

Table 2. Counties Most Vulnerable to Winter Storm (shade indicates most vulnerable)

	Vulnerable to Meteorological Conditions	Recurrence Chance / Year (>50% – At least one occurrence every two years)
Adams	NO	35%
Asotin	YES	23%
Benton	NO	48%
Chelan	YES	23%
Clallam	YES	48%
Clark	YES, East County	85%
Columbia	YES	38%
Cowlitz	YES	60%
Douglas	YES	143%
Ferry	YES	23%
Franklin	NO	33%
Garfield	YES	73%
Grant	YES	60%
Grays Harbor	NO	40%
Island	NO	43%
Jefferson	YES	43%
King	YES	70%
Kitsap	YES	35%
Kittitas	YES	110%
Klickitat	YES	38%
Lewis	YES	33%
Lincoln	YES	25%
Mason	YES	60%
Okanogan	YES	128%
Pacific	NO	33%
Pend Oreille	YES	28%
Pierce	YES	60%
San Juan	YES	48%
Skagit	YES	58%
Skamania	YES	88%
Snohomish	YES	58%
Spokane	YES	55%
Stevens	YES	28%
Thurston	YES	50%
Wahkiakum	NO	35%
Walla Walla	YES	98%
Whatcom	YES	65%
Whitman	YES	30%
Yakima	YES	73%

Table 3. Counties Most Vulnerable to Blizzard (shade indicates most vulnerable)

	Vulnerable to Meteorological Conditions	Recurrence Chance / Year (>2.5% - At least one occurrence every 40 years)
Adams	YES	0%
Asotin	YES	0%
Benton	NO	0%
Chelan	NO	0%
Clallam	NO	0%
Clark	YES	0%
Columbia	NO	0%
Cowlitz	NO	0%
Douglas	YES	0%
Ferry	YES, Higher Elevations	0%
Franklin	NO	0%
Garfield	NO	3%
Grant	YES	0%
Grays Harbor	NO	0%
Island	NO	0%
Jefferson	NO	0%
King	NO	3%
Kitsap	NO	0%
Kittitas	NO	3%
Klickitat	NO	0%
Lewis	NO	0%
Lincoln	YES	0%
Mason	NO	0%
Okanogan	YES, Higher Elevations	3%
Pacific	NO	0%
Pend Oreille	YES, Higher Elevations	0%
Pierce	NO	0%
San Juan	NO	0%
Skagit	NO	0%
Skamania	YES	0%
Snohomish	NO	0%
Spokane	NO	0%
Stevens	YES, Higher Elevations	0%
Thurston	NO	0%
Wahkiakum	NO	0%
Walla Walla	NO	3%
Whatcom	YES	3%
Whitman	YES	0%
Yakima	NO	0%

Table 4. Counties Most Vulnerable to Dust Storm (shade indicates most vulnerable)

	Vulnerable to Meteorological Conditions	Recurrence Chance / Year (>2.5% - At least one occurrence every 40 years)
Adams	YES	8%
Asotin	NO	3%
Benton	YES	18%
Chelan	NO	5%
Clallam	NO	0%
Clark	NO	0%
Columbia	YES	3%
Cowlitz	NO	0%
Douglas	YES	10%
Ferry	NO	5%
Franklin	YES	8%
Garfield	YES	0%
Grant	YES	13%
Grays Harbor	NO	0%
Island	NO	0%
Jefferson	NO	0%
King	NO	0%
Kitsap	NO	0%
Kittitas	NO	5%
Klickitat	NO	3%
Lewis	NO	0%
Lincoln	YES	10%
Mason	NO	0%
Okanogan	NO	8%
Pacific	NO	0%
Pend Oreille	NO	3%
Pierce	NO	0%
San Juan	NO	0%
Skagit	NO	0%
Skamania	NO	3%
Snohomish	NO	0%
Spokane	YES	8%
Stevens	NO	5%
Thurston	NO	0%
Wahkiakum	NO	0%
Walla Walla	YES	8%
Whatcom	NO	0%
Whitman	YES	5%
Yakima	YES	8%

Table 5. Counties Most Vulnerable to Severe Thunderstorms (shade indicates most vulnerable)

	Vulnerable to Meteorological Conditions	Recurrence Chance / Year (>20% - At least one occurrence every five years)
Adams	YES	30%
Asotin	YES	25%
Benton	YES	35%
Chelan	YES	30%
Clallam	NO	5%
Clark	NO	8%
Columbia	YES	13%
Cowlitz	NO	8%
Douglas	YES	20%
Ferry	YES	43%
Franklin	YES	38%
Garfield	YES	33%
Grant	YES	63%
Grays Harbor	NO	8%
Island	NO	10%
Jefferson	NO	5%
King	NO	15%
Kitsap	NO	3%
Kittitas	YES	8%
Klickitat	YES	13%
Lewis	NO	3%
Lincoln	YES	50%
Mason	NO	5%
Okanogan	YES	45%
Pacific	NO	3%
Pend Oreille	YES	30%
Pierce	NO	5%
San Juan	NO	8%
Skagit	NO	8%
Skamania	YES	3%
Snohomish	NO	15%
Spokane	YES	75%
Stevens	NO	60%
Thurston	NO	8%
Wahkiakum	NO	3%
Walla Walla	YES	58%
Whatcom	NO	8%
Whitman	YES	43%
Yakima	YES	40%

Table 6. Counties Most Vulnerable to Tornado (shade indicates most vulnerable)

	Vulnerable to Meteorological Conditions	Recurrence Chance / Year (>5.0% - At least one occurrence every 20 years)
Adams	YES	8%
Asotin	YES	0%
Benton	YES	3%
Chelan	NO	0%
Clallam	NO	0%
Clark		15%
Columbia	YES	5%
Cowlitz		5%
Douglas	NO	3%
Ferry	NO	0%
Franklin	YES	5%
Garfield	YES	3%
Grant	YES	8%
Grays Harbor		5%
Island	NO	0%
Jefferson	NO	0%
King	NO	13%
Kitsap	NO	3%
Kittitas	NO	0%
Klickitat	YES	0%
Lewis	NO	3%
Lincoln	YES	13%
Mason	NO	0%
Okanogan	NO	13%
Pacific	NO	5%
Pend Oreille	YES	3%
Pierce	NO	13%
San Juan	NO	3%
Skagit	NO	0%
Skamania	NO	0%
Snohomish	NO	10%
Spokane	YES	33%
Stevens	YES	10%
Thurston	NO	3%
Wahkiakum	NO	0%
Walla Walla	YES	13%
Whatcom	NO	0%
Whitman	YES	5%
Yakima	YES	10%

Table 7. Counties Most Vulnerable to Coastal Flooding (shade indicates most vulnerable)

	Vulnerable to Meteorological Conditions	Recurrence Chance / Year (>2.5% - At least one occurrence every 40 years)
Adams	NO	0%
Asotin	NO	0%
Benton	NO	0%
Chelan	NO	0%
Clallam	YES	15%
Clark	NO	0%
Columbia	NO	0%
Cowlitz	NO	0%
Douglas	NO	0%
Ferry	NO	0%
Franklin	NO	0%
Garfield	NO	0%
Grant	NO	0%
Grays Harbor	YES	23%
Island	YES	0%
Jefferson	YES	10%
King	YES	10%
Kitsap	YES	15%
Kittitas	NO	0%
Klickitat	NO	0%
Lewis	NO	0%
Lincoln	NO	0%
Mason	NO	0%
Okanogan	NO	0%
Pacific	YES	20%
Pend Oreille	NO	0%
Pierce	YES	3%
San Juan	YES	5%
Skagit	YES	10%
Skamania	NO	0%
Snohomish	YES	8%
Spokane	NO	0%
Stevens	NO	0%
Thurston	NO	8%
Wahkiakum	NO	0%
Walla Walla	NO	0%
Whatcom	YES	18%
Whitman	NO	0%
Yakima	NO	0%

State Agency Structures At Risk			PRELIMINARY ASSESSMENT
Number and Function of Buildings	**No. of Affected Staff / Visitors / Residents**	**Approx. Value of Owned Structures**	**Approx. Value of Contents All Buildings**
Total at-risk buildings: State agencies participating in this plan identified 2,115 facilities as being potentially at-risk to direct damage or to the indirect impacts of severe storms of all types (utility services reductions, transportation restrictions, etc.).	312,729	$9,437,748,270	$3,514,023,597

Function of at-risk buildings: Included in the facilities potentially at-risk to severe storms are the following:

- Buildings of the State Capitol Campus, and nearby headquarters offices of nearly all agencies of state government.
- Main campuses of Western Washington University and the University of Washington; and the marine laboratories they operate.
- Harborview Medical Center, Children's Hospital, and the UW Hospital, all on or near the main University of Washington campus.
- University of Washington branch campuses in Bothell and Tacoma.
- Campuses of Big Bend Community College, Everett Community College, Seattle Central Community College, and South Puget Sound Community College.
- A campus leased to the federal government used for a Job Corps Center.
- Campuses of Francis Haddon Morgan, Rainier School, Western State Hospital, Eastern State Hospital, Fircrest School, Yakima Valley School and Lakeland Village for individuals with physical and mental disabilities.
- Campuses of Maple Lane School, Green Hill School, Naselle Youth Camp, and Echo Glen Children's Center for juvenile offenders.
- Special Confinement Center for sexual offenders.
- Regional headquarters, local detachments, highway weigh scales, and communication facilities of the Washington State Patrol.
- Hundreds of general office and client service offices that include those serving individuals and families on public assistance, providing employment and training services, driver licensing, and liquor sales.

More detailed narratives on at-risk facilities can be found in the Region profiles, Tab 7.2.1 – Tab 7.2.9.

Total at-risk critical facilities: State agencies participating in this plan identified 763 critical facilities as being potentially at-risk to direct damage or to the indirect impacts of severe storms of all types (utility services reductions, transportation restrictions, etc.).	83,823	$3,825,399,630	$2,093,350,529

Function of at-risk critical facilities: Included in the facilities potentially at-risk to severe storms are the following:

- Buildings of the State Capitol Campus, and nearby headquarters offices of nearly all agencies of

state government.

- Buildings on the main campuses of Western Washington University and the University of Washington; and the marine laboratories they operate.
- Buildings on the campuses of Everett Community College, Seattle Central Community College, and South Puget Sound Community College.
- Buildings on campuses for individuals with physical and mental disabilities, and for juvenile offenders.
- Regional headquarters, local detachments, highway weigh scales, and communication facilities of the Washington State Patrol.
- State liquor stores and driver licensing offices.
- Hundreds of general office and client service offices that include those serving individuals and families on public assistance, providing employment and training services, driver licensing, and liquor sales.

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[1] *Washington State 2001 Hazard Identification and Vulnerability Assessment*, Washington State Military Department, Emergency Management Division, April 2001.

[2] Notes from and personal communication with Ted Buehner, Warning Coordination Meteorologist, National Weather Service, Seattle Forecast Office, April 2, 2003.

[3] *Climate of Washington*, Western Regional Climate Center, Desert Research Institute, http://www.wrcc.dri.edu/narratives/WASHINGTON.htm, (February 20, 2003).

[4] Notes from Ted Buehner, Warning Coordination Meteorologist, National Weather Service, Seattle Forecast Office, April 2, 2003.

[5] Chris Hill et al., *Top Ten 20th Century Weather Events In Washington State*, National Weather Service, Seattle Forecast Office, December 1999, <http://www.seawfo.noaa.gov/WATOP10.htm>, (February 20, 2003).

[6] Ibid.

[7] Ibid.

[8] Ibid.

[9] Eric Sorensen, *Columbus Day 1962, Memories of Storm That Roared Still Vivid*, Seattle Times, October 6, 2002.

[10] Ibid.

[11] Fujita Tornado Measurement Scale, *Understanding Your Risks: Identifying Hazards and Estimating Losses*, Federal Emergency Management Agency, FEMA 386-2, August 2001.

[12] Information from *Flood Mitigation Implementation Measures Report for Whatcom County, FEMA-676-DR*, Washington State Department of Emergency Services et al., November 1983.

[13] Chris Hill et al., *Top Ten 20th Century Weather Events In Washington State*, National Weather Service, Seattle Forecast Office, December 1999, <http://www.seawfo.noaa.gov/WATOP10.htm>, (February 20, 2003).

[14] Unless otherwise noted, disaster assistance costs come from spreadsheet maintained by State Hazard Mitigation Officer for assistance programs managed by Washington Military Department, Emergency Management Division, (February 20, 2003). Typically, total disaster costs are about twice the total shown.

[15] Chris Hill et al., *Top Ten 20th Century Weather Events In Washington State*, National Weather Service, Seattle Forecast Office, December 1999, <http://www.seawfo.noaa.gov/WATOP10.htm>, (February 20, 2003).

[16] Information from *Inauguration Day Wind Storm January 20, 1993 After-Action Report*, Washington State Department of Community Development, August 1993.

[17] Chris Hill et al., *Top Ten 20th Century Weather Events In Washington State*, National Weather Service, Seattle Forecast Office, December 1999, <http://www.seawfo.noaa.gov/WATOP10.htm>, (February 20, 2003).

[18] Information from *Interagency Hazard Mitigation Team Report, with Early Implementation Strategies for DR-1079-WA and DR-1100-WA*, Federal Emergency Management Agency Region X, July 1996.

[19] Chris Hill et al., *Top Ten 20th Century Weather Events In Washington State*, National Weather Service, Seattle Forecast Office, December 1999, <http://www.seawfo.noaa.gov/WATOP10.htm>, (February 20, 2003).

[20] Information from *Hazard Mitigation Survey Team Report for the 1996-1997 Washington Winter Storms*, Washington State Emergency Management Division and the Federal Emergency Management Agency Region 10, 1997.

[21] Ibid.

[22] Chris Hill et al., *Top Ten 20th Century Weather Events In Washington State*, National Weather Service, Seattle Forecast Office, December 1999, <http://www.seawfo.noaa.gov/WATOP10.htm>, (February 20, 2003).

[23] Fujita Tornado Measurement Scale, *Understanding Your Risks: Identifying Hazards and Estimating Losses*, Federal Emergency Management Agency, FEMA 386-2, August 2001.

[24] Summary tables of hazardous weather fatalities, injuries, and damage costs listed by state, for years 1995 through 2001, National Oceanic and Atmospheric Administration, National Weather Service.